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Hawaii Agricultural Experiment Station

HONOLULU

J. M. WESTGATE, Agronomist in Charge

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Composition and Digestibility of Feeding Stuffs Grown in Hawaii

By

MAXWELL O. JOHNSON, *Chemist*

and

KIM AK CHING, *Assistant Chemist*

INTRODUCTION

The present shortage in feeding stuffs and the possibility that communication between the mainland and the Hawaiian Islands may be interrupted demand that every effort should be made to increase the supply of feeding stuffs grown in Hawaii. The Hawaii Agricultural Experiment Station has issued at various times a number of publications[1] dealing with the cultivation of local crops for use as feeding stuffs.

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[1] Krauss, F. G., Hawaii Sta. Bul. 23 (1911); McClelland, C. K., Hawaii Sta. Bul. 36 (1915), Press Buls. 40 and 42 (1913). See also Hawaii Sta. Reports.

ANALYSES OF HAWAIIAN FEEDING STUFFS

In seeking new sources of supply of feeding stuffs, in determining their relative values, and in calculating rations for live stock, the determination of the chemical composition of feeding stuffs is of very great importance. The chemistry department of the Hawaii Agricultural Experiment Station has from time to time published analyses of samples of local feeding stuffs. The majority of these analyses were made by E. C. Shorey[1] and a number by Miss A. R. Thompson[2]. A number of analyses have been performed by the present chemist of the station. In order that the data secured may be of the greatest service in the present emergency, all the analyses so far made have been collected in Table I, where they are arranged in a form convenient for comparison with standard tables of American feeding stuffs, such as those of Henry and Morrison[3].

It is believed that the analyses of most of the important feeding stuffs produced in Hawaii are given in Table I. If any have been omitted, samples will be analyzed if about one pound of material in the condition in which it is usually fed to live stock is forwarded to the station.

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[1] Hawaii Sta. Bul. 13 (1913).

[2] Hawaii Sta. Rpt. 1907, pp. 63-66; 1908, pp. 58, 59.

[3] Henry, W. A., and Morrison, F. B. Feeds and Feeding. Madison, Wis., 1915, 15 ed., rev., pp. 691.

TABLE I.—PERCENTAGE COMPOSITION OF HAWAIIAN FEEDING STUFFS

Feeding Stuff	Water	Ash	Crude Protein	—Carbohydrates—		Fat
				Fiber	Nitrogen-free Extract	
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
FRESH GREEN ROUGHAGE						
NON-SACCHARIN AND SACCHARIN SORGHUMS:						
Sorghum:						
Sample No. 1	78.12	1.77	1.28	5.75	12.72	.36
Sample No. 2	62.56	2.88	1.98	10.15	22.05	.38
Sample No. 3	79.10	2.16	.77	8.23	8.98	.76
Sample No. 4	74.43	1.75	2.15	10.17	11.11	.39
Sample No. 5	81.50	1.60	.78	6.60	9.33	.19
Average	75.14	2.03	1.39	8.18	12.84	.42
Sugar-cane tops:						
Sample No. 1	71.12	1.64	1.60	7.20	18.09	.35
Sample No. 2	75.98	1.52	1.78	7.75	12.51	.46
Sample No. 3	76.30	1.50	1.23	6.98	13.54	.45
Average	74.47	1.55	1.54	7.31	14.71	.42
Hog or broom corn millet:						
Sample No. 1	75.53	1.79	2.81	7.45	12.05	.37
Sample No. 2	80.82	1.80	2.07	6.79	8.44	.08
Average	78.18	1.79	2.44	7.12	10.25	.22

TABLE I.—PERCENTAGE COMPOSITION OF HAWAIIAN FEEDING STUFFS—Cont.

Feeding Stuff	Water	Ash	Crude Protein	Carbohydrates		Fat
				Fiber	Nitrogen-free Extract	
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
FRESH GREEN ROUGHAGE—con.						
Kafir Corn:						
Sample No. 1	79.69	.97	1.65	6.66	10.86	.17
Sample No. 2	87.13	1.36	1.63	7.05	2.60	.23
Average	83.41	1.17	1.64	6.85	6.73	.20
GRASSES:						
Guinea grass:						
Sample No. 1	63.93	4.29	1.88	8.29	21.42	.19
Sample No. 2	65.02	3.45	2.03	11.68	17.39	.43
Average	64.48	3.87	1.95	9.98	19.41	.31
Para grass:						
Sample No. 1	79.72	2.07	2.00	7.89	8.18	.14
Sample No. 2	71.42	3.81	1.91	10.00	12.56	.30
Sample No. 3	71.51	2.11	2.66	11.68	11.61	.43
Sample No. 4	75.75	3.23	2.55	6.85	11.32	.30
Average	74.60	2.81	2.28	9.10	10.92	.29

TABLE I.—PERCENTAGE COMPOSITION OF HAWAIIAN FEEDING STUFFS—Cont.

FEEDING STUFF	Water	Ash	Crude Protein	Carbohydrates		Fat
				Fiber	Nitrogen-free Extract	
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
FRESH GREEN ROUGHAGE—con.						
Australian water grass (*Paspalum dilatatum*):						
Sample No. 1	75.77	2.47	2.82	7.32	10.97	.65
Sample No. 2	71.47	2.58	3.09	11.06	11.17	.63
Sample No. 3	72.95	2.13	1.96	8.86	13.38	.72
Average	73.40	2.39	2.62	9.08	11.84	.67
Paspalum orbiculare	57.13	3.70	2.13	13.65	22.93	.46
Barnyard grass	84.97	1.54	1.85	5.80	5.51	.33
Bermuda grass	45.49	5.36	3.71	12.50	32.62	.32
Buffalo grass	63.09	2.46	1.44	9.90	22.73	.38
Pilipiliuli (*Chrysopogon aciculatus*)	41.03	3.23	3.09	16.26	36.04	.36
Kukaipua (*Syntherisma sanguinalis*)	58.96	4.12	4.50	11.90	19.99	.53
Pili grass (*Heteropogon contortus*)	45.32	6.33	2.65	17.80	27.14	.76
Yard grass	77.77	2.72	1.87	7.45	9.17	1.02
Chloris elegans	64.85	4.20	2.75	11.25	16.44	.51
Hilo grass (*Paspalum conjugatum*):						
Sample No. 1	70.48	1.73	1.52	9.44	16.43	.40
Sample No. 2	71.70	1.76	1.43	9.39	15.18	.54
Sample No. 3	73.20	1.49	1.38	9.05	14.02	.86
Sample No. 4	70.07	2.47	1.41	8.96	16.28	.86
Average	71.36	1.86	1.43	9.21	15.48	.66

TABLE I.—PERCENTAGE COMPOSITION OF HAWAIIAN FEEDING STUFFS—Cont.

Feeding Stuff	Water	Ash	Crude Protein	Carbohydrates		Fat
				Fiber	Nitrogen-free Extract	
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
FRESH GREEN ROUGHAGE—con.						
Rhodes grass	64.79	3.26	2.81	12.54	16.08	.52
Side oats grama (partly dried)	39.47	7.25	6.43	18.12	27.68	1.05
English and Italian rye grass (partly dried)	27.44	7.02	6.49	20.94	36.68	1.43
LEGUMINOUS FORAGE CROPS:						
Alfalfa:						
Sample No. 1	84.75	2.18	5.23	4.19	3.30	.35
Sample No. 2	68.13	3.60	7.31	10.32	10.20	.44
Sample No. 3	70.46	2.84	5.59	7.89	12.74	.48
Sample No. 4	76.61	2.87	6.78	4.24	8.73	.77
Sample No. 5	73.83	3.39	5.25	5.56	11.21	.76
Sample No. 6	72.18	3.39	8.00	6.27	9.44	.72
Average	74.33	3.04	6.36	6.41	9.27	.59
Cowpea:						
Sample No. 1	86.16	1.50	2.63	4.19	5.40	.12
Sample No. 2	82.35	2.55	3.06	4.22	7.24	.58
Average	84.26	2.02	2.84	4.21	6.32	.35

TABLE I.—PERCENTAGE COMPOSITION OF HAWAIIAN FEEDING STUFFS—Cont

Feeding Stuff	Water	Ash	Crude Protein	—Carbohydrates—		Fat
				Fiber	Nitrogen-free Extract	
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
FRESH GREEN ROUGHAGE—con.						
Wild cowpea (*Vigna sandwichensis*)	73.11	1.38	3.47	8.61	13.25	.18
Desmodium triflorum	65.22	2.76	5.03	11.65	13.92	1.42
Pigeon pea (*Cajanus indicus*)	70.00	2.64	7.11	10.72	7.88	1.65
Jack bean (*Canavali ensiformis*)	76.81	2.70	5.21	6.36	8.44	.48
Spanish clover *Desmodium uncinatum*	75.06	.98	2.20	7.21	14.36	.19
WEEDS USED AS FORAGE:						
Pigweed (*Portulaca oleracea*)	95.20	.96	1.04	.53	2.18	.09
Pualele (*Sonchus oleraceus*)	87.13	1.93	1.78	2.57	5.85	.74
Honohono (*Commelina nudiflora*):						
Sample No. 1	86.45	1.47	1.17	2.64	7.78	.49
Sample No. 2	92.41	1.33	1.38	1.92	2.81	.15
Average	89.43	1.40	1.27	2.28	5.30	.32
Ki or Spanish needles (*Bidens pilosa*):						
Sample No. 1	67.92	2.74	2.15	7.15	19.59	.45
Sample No. 2	82.06	2.65	3.45	5.03	6.48	.33
Average	74.99	2.69	2.80	6.09	13.04	.39

TABLE I.—PERCENTAGE COMPOSITION OF HAWAIIAN FEEDING STUFFS—Cont.

Feeding Stuff	Water	Ash	Crude Protein	Carbohydrates		Fat
				Fiber	Nitrogen-free Extract	
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
FRESH GREEN ROUGHAGE—con.						
Miscellaneous Green Forage:						
Prickly pear:						
Young fronds	94.63	1.12	.44	.52	3.22	.07
Old fronds	94.62	1.13	.39	.61	3.16	.09
Average	94.63	1.12	.41	.57	3.19	.08
Kolu (*Acacia farnesiana*)	60.00	2.10	6.87	7.16	23.04	.83
Banana tops	84.29	1.74	2.08	4.91	6.62	.36
Banana butts	94.22	1.05	.37	2.20	2.02	.14
Taro tops	84.56	1.38	1.86	1.42	10.29	.49
Sweet potato tops	87.67	1.27	2.93	1.69	6.08	.36
Ti (*Cordyline terminalis*) leaves	79.36	1.87	2.86	6.38	8.90	.63
Pakana (*Melilotus officinalis*)	61.28	2.60	5.96	11.90	17.59	.67
Rape	86.10	2.71	2.24	1.76	6.60	.59
Annual ilima (*Sida sp.*)	77.58	3.53	3.93	5.69	8.88	.39
Sisal waste (average of all samples)	84.11	1.58	.94	2.79	10.58	.00

TABLE I.—PERCENTAGE COMPOSITION OF HAWAIIAN FEEDING STUFFS—Cont.

FEEDING STUFF	Water	Ash	Crude Protein	—Carbohydrates— Fiber	Nitrogen-free Extract	Fat
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
FRESH GREEN ROUGHAGE—con.						
ROOT CROPS USED AS FORAGE:						
Cassava peeling	68.75	2.86	.99	3.58	23.30	.52
Cassava peeled roots	65.30	.55	.69	.71	32.62	.13
Cassava whole roots:						
Sample No. 1	65.55	.72	.71	.92	31.94	.16
Sample No. 2	62.80	1.00	.83	1.45	30.89	3.03
Average	64.17	.86	.77	1.19	31.42	1.59
Cassava refuse (from crude extract of starch)	15.46	.85	1.21	5.45	76.93	.10
Cassava waste (first washing for starch manufacture)	16.30	1.27	1.31	1.08	79.82	.22
Edible canna:						
Sample No. 1 (2 inch rootstocks)	81.58	.81	1.37	.54	15.57	.13
Sample No. 2 (5-6 inch ")	65.86	.81	1.20	.64	31.34	.15
Average	73.72	.81	1.28	.59	23.46	.14

TABLE I.—PERCENTAGE COMPOSITION OF HAWAIIAN FEEDING STUFFS—Cont.

Feeding Stuff	Water	Ash	Crude Protein	Carbohydrates		Fat
				Fiber	Nitrogen-free Extract	
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Taro waste	70.73	4.36	.36	.89	23.42	.24
Tacca pinnatifida	66.89	.84	1.93	.58	29.64	.12
Beet, yellow tankard	94.12	1.25	1.00	.97	2.62	.04
Beet, long red	93.25	1.17	1.13	2.59	1.80	.06
Ti (*Cordyline terminalis*) root (fresh)	67.34	.49	2.06	2.12	27.92	.07
Ti root (partly dried)	46.78	1.62	3.76	5.40	42.32	.16
Taro whole root	60.55	.73	1.10	.58	36.91	.13
Taro peeling	78.75	1.01	.66	1.23	18.14	.21
Taro peeled root	58.35	.69	1.16	.51	39.17	.12
Sweet potato whole root	68.89	.90	2.12	.81	27.02	1.26
Sweet potato peeling	74.35	.31	1.29	.33	21.63	1.09
Sweet potato peeled root	68.50	.94	2.18	.77	27.41	.20
SILAGE:						
Sorghum silage	76.76	2.17	2.04	5.68	12.62	.73
Corn cut for silo	76.45	2.57	1.64	6.43	12.67	.24
Corn silage	81.63	5.04	2.06	4.35	6.61	.31
Para grass silage	80.48	1.69	1.15	8.47	7.94	.21

TABLE I.—PERCENTAGE COMPOSITION OF HAWAIIAN FEEDING STUFFS—Cont.

FEEDING STUFF	Water	Ash	Crude Protein	Carbohydrates		Fat
				Fiber	Nitrogen-free Extract	
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
DRIED ROUGHAGE						
HAY FROM GRASSES:						
Redtop	8.84	5.95	3.38	35.48	45.14	1.21
Rhodes grass:						
Sample No. 1	10.87	13.19	9.00	27.36	38.05	1.53
Sample No. 2	11.75	7.15	6.08	30.20	42.51	2.31
Sample No. 3	9.87	7.64	7.25	29.21	44.64	1.39
Average	10.83	9.33	7.44	28.92	41.73	1.74
Panicum plicatum	9.14	15.87	4.62	23.36	45.32	1.69
Foxtail grass	9.97	10.58	8.40	31.76	38.20	1.09
Sudan grass	9.48	8.71	7.64	33.48	38.97	1.72
Tunis grass	9.48	9.06	5.68	36.45	37.94	1.39
Rescue grass	9.37	7.67	10.75	33.75	36.07	2.39
Australian blue grass	9.48	6.58	5.72	39.12	37.29	1.81
Natal redtop	9.46	8.37	4.25	38.01	38.10	1.81
SMALL CEREAL STRAWS:						
Wheat straw	9.44	7.32	4.48	31.80	45.14	1.82
Wheat straw containing a little oats	11.91	10.83	7.96	30.09	38.27	.94
Rice straw	10.89	19.88	4.81	24.84	36.91	2.67

TABLE I.—PERCENTAGE COMPOSITION OF HAWAIIAN FEEDING STUFFS—Cont.

Feeding Stuff	Water	Ash	Crude Protein	Carbohydrates Fiber	Carbohydrates Nitrogen-free Extract	Fat
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
DRIED ROUGHAGE—con.						
Meal From Hay:						
Sudan grass meal	10.77	5.68	5.37	36.89	40.75	.54
Velvet bean vine meal (seed removed)	11.84	6.26	17.15	36.09	28.00	.66
Pigeon pea meal (seed removed)	10.15	3.70	16.53	42.86	25.54	1.22
Sunn hemp meal	10.71	3.19	10.67	45.89	29.00	.54
Cowpea vine meal (seed removed)	11.68	8.42	14.96	32.30	30.97	1.67
Mixed feed consisting of 2 parts velvet bean vine meal, 1 part Sudan grass meal, & 1 part cane-top meal	11.25	4.93	15.57	36.56	30.25	1.44
Mixed feed consisting of equal parts by weight of cowpea meal, algaroba meal, & molascuit (80% molasses)	11.61	7.67	13.65	23.81	42.25	1.01
Roots and By-Products:						
Cassava peeling	12.00	8.07	2.80	10.09	65.57	1.47
Taro peeling	12.51	4.13	2.71	5.08	74.70	.87
Sweet potato peeling	12.81	1.06	4.37	4.51	73.56	3.69
Cassava whole root	12.43	1.83	1.81	2.34	81.18	.41
Taro whole root	12.13	1.63	2.46	1.29	82.20	.29
Sweet potato whole root	11.52	2.56	6.02	2.30	76.86	.74
Cassava peeled root	12.47	1.40	1.75	1.79	82.27	.32

TABLE I.—PERCENTAGE COMPOSITION OF HAWAIIAN FEEDING STUFFS—Cont.

Feeding Stuff	Water	Ash	Crude Protein	Carbohydrates		Fat
				Fiber	Nitrogen-free Extract	
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
DRIED ROUGHAGE—con.						
Taro peeled root	12.09	.69	2.45	1.07	82.68	.25
Sweet potato peeled root	11.43	2.65	6.12	2.16	77.09	.55
Hog or broomcorn millet roots	11.18	12.83	7.22	40.82	27.56	.39
Miscellaneous:						
Sisal waste	5.00	11.24	5.78	17.97	60.01	.00
CONCENTRATES						
Brewers' Grains	9.05	3.71	18.06	20.34	46.08	2.76
Molascuit:						
Sample No. 1	26.00	7.02	4.20	7.00	55.68	.10
Sample No. 2	15.66	7.66	4.54	10.86	61.12	.16
Sample No. 3	21.95	9.20	2.27	6.96	59.57	.05
Average	21.20	7.96	3.67	8.27	58.80	.10

TABLE I.—PERCENTAGE COMPOSITION OF HAWAIIAN FEEDING STUFFS—Cont.

Feeding Stuff	Water	Ash	Crude Protein	Carbohydrates		Fat
				Fiber	Nitrogen-free Extract	
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
CONCENTRATES—con.						
Algaroba or Kiawe bean:						
Sample No. 1	15.61	2.89	9.37	22.88	48.62	.63
Sample No. 2	14.91	3.61	8.41	26.63	45.91	.53
Sample No. 3	13.62	3.33	8.13	21.87	52.38	.67
Sample No. 4	16.37	3.44	8.50	17.47	53.77	.44
Sample No. 5	15.17	3.82	9.73	23.71	47.12	.45
Average	15.14	3.42	8.83	22.51	49.56	.54
Algaroba meal:						
Sample No. 1	5.10	3.67	9.56	21.14	59.86	.67
Sample No. 2	9.29	3.52	10.25	27.85	47.98	1.11
Average	7.19	3.59	9.91	24.49	53.92	.89
Seed and pod 1 year old	11.36	3.17	9.87	23.65	51.52	.43
Seed and pod fresh bean	12.30	3.20	7.34	19.48	57.31	.37
Seed coats	12.57	2.06	5.00	32.74	47.26	.37
Selected pods, seed removed	18.15	2.68	6.52	20.20	53.33	.12
Seed from selected pods	14.38	4.44	33.62	6.84	36.78	3.94
Average pods, seed removed	17.49	3.15	4.62	22.52	52.07	.15
Seed from average pods	14.24	4.40	30.18	7.78	38.90	4.50

TABLE I.—PERCENTAGE COMPOSITION OF HAWAIIAN FEEDING STUFFS—Cont.

Feeding Stuff	Water	Ash	Crude Protein	Carbohydrates		Fat
				Fiber	Nitrogen-free Extract	
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
CONCENTRATES—con.						
Rice bran:						
Sample No. 1	9.55	12.16	7.12	28.97	31.19	11.01
Sample No. 2	10.63	10.07	11.33	10.33	45.57	12.07
Average	10.09	11.11	9.23	19.65	38.38	11.54
Rice polish	10.49	8.87	12.31	5.18	50.18	12.97
Coconut meal	11.18	5.74	20.97	12.97	41.62	7.52
Pigeon pea meal	9.67	4.51	19.08	10.57	54.49	1.68
Cowpea meal	9.86	3.72	20.88	6.33	57.47	1.74
Jack bean meal	7.18	3.81	21.53	9.91	55.06	2.51
Corn-and-cob meal	13.52	1.58	10.03	4.54	67.98	2.35
Velvet bean meal (seed and pod)	12.47	6.57	23.01	6.50	47.91	3.54
Soy bean waste (original)	77.68	2.96	4.90	.17	14.28	.01
Soy bean waste (air dry)	4.07	12.77	21.12	.74	61.26	.04
Sake waste	63.47	.58	14.84	1.67	18.76	.68
Molasses	23.33	8.66	2.34	.00	65.42	.25

The analyses in Table I were made according to the methods adopted by the Association of Official Agricultural Chemists.[1] The crude protein represents all the nitrogenous constituents of the feeding stuff and consists chiefly of the proteids, which are necessary to supply new tissue for replacing the body waste and for growth, milk production, etc. The fiber is the material left after boiling the sample with sulphuric acid and with caustic soda and represents roughly the woody matter. It has a low nutritive value, but a portion of it is digested by animals. The nitrogen-free extract represents the starch, sugar, and similar substances in the feed and usually has a high nutritive value. In Table I, the crude fiber and nitrogen-free extract are grouped together as carbohydrates, according to the method used by Henry and Morrison.[2] The fat represents the material extracted from the feeding stuff by ether. In concentrates such as middlings and oil meal, the so-called fat, or ether extract, consists mainly of fats and oils, but in roughages other substances may be present in large amount. The digested carbohydrates and fats are used to produce fat and to supply the energy necessary for work and for the body activities. Excess of digested protein may also be used for the same purposes. The ash represents the mineral constituents of the feeding stuff left after ignition. The importance of the mineral constituents to animals is being increasingly recognized. Lime and phosphoric acid are usually the most important. Shorey[3] has pointed out the very low lime content of many Hawaiian feeding stuffs and the value of his suggestions has been recognized by those raising live stock in Hawaii.

DIGESTIBILITY OF FEEDING STUFFS

It has been found by experiments on living animals in which the feed fed is weighed and analyzed as are likewise the excretory products, that only a part of the total amount of each nutrient in a feed is digested. Such experiments performed on a large number of animals are used in determining the average "coefficient of digestibility" for each nutrient, such as crude protein, fat, etc. This coefficient of digestibility represents the average percentage of the total amount of each nutrient which is digested by the animal body and thus becomes capable of utilization. It has been found by experiment that the digestibility of feeds is affected to some extent by a variety of causes, such as the kind of animal fed, the composition of the rations, the preparation of the feed, etc. The total amount of each nutrient in 100 pounds of a feed, multiplied by the coefficient of digestibility for that nutrient gives the average amount of the digestible nutrient per 100 pounds. Unfortunately, up to the present time, the necessary money and equipment have not been available for determining by an extensive series of slow and costly feeding experiments the average digestibility of Hawaiian feeding stuffs. Until such experiments can be carried out, it is necessary to assume that the average digestibility of the nutrients in the various Hawaiian feeding stuffs is approximately the same as for similar materials produced on the mainland for which digestibility data have been secured. Since a comparison of the analyses of the various Hawaiian feeding stuffs with similar mainland materials shows that their compositions are similar, there would probably not be very great error in assuming similar digestibilities. On this assumption it is possible to calculate approximate digestible nutrients of Hawaiian feeding stuffs, which, though not strictly accurate, are of value as the best data available at present. It should be remembered that all figures showing digestible nutrients in feeding stuffs are only approximate, as digestibility is a variable factor for which average values only can be secured. The approximate digestible nutrients of Hawaiian feeding stuffs are given in Table II.

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[1] U. S. Dept. Agr., Bur. of Chem. Bul. 107 (1907), pp. 38-58.

[2] Loc. cit.

[3] Loc. cit.

TABLE II

ESTIMATED DIGESTIBLE NUTRIENTS OF HAWAIIAN FEEDING STUFFS

Feeding Stuff	Total dry matter in 100 pounds	Digestible nutrients in 100 pounds				Nutritive Ratio
		Crude protein	Carbohydrate	Fat	Total	
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	1:
FRESH GREEN ROUGHAGE						
NON-SACCHARIN AND SACCHARIN SORGHUMS:						
Sorghum	24.86	.6	13.9	.3	15.2	24.3
Sugar-cane tops	25.53	.7	14.8	.3	16.2	22.1
Hog millet	21.82	1.5	12.1	.1	13.8	8.2
Kafir corn	16.59	1.0	8.6	.1	9.8	8.8
GRASSES:						
Guinea grass	35.52	.9	18.4	.2	19.7	20.8
Para grass	25.40	1.1	10.0	.1	11.3	9.2
Australian water grass (*Paspalum dilatatum*)	26.60	1.2	10.5	.3	12.4	9.3
Paspalum orbiculare	42.87	1.0	18.3	.2	19.7	18.7
Barnyard grass	15.03	1.3	7.9	.2	9.6	6.4
Bermuda grass	54.51	1.8	22.5	.1	24.5	12.6
Buffalo grass (*manie-akiaki*)	36.91	.8	19.7	.2	20.9	25.1
Pilipiliuli (*Chrysopogon aciculatus*)	59.00	1.5	26.1	.2	28.0	17.6
Kukaipua (*Syntherisma sanguinalis*)	41.04	2.2	16.0	.2	18.6	7.4
Pili grass (*Heteropogon contortus*)	54.68	1.3	22.5	.4	24.7	18.0
Yard grass	22.23	1.3	11.8	.6	14.4	10.0
Chloris elegans	35.15	1.3	13.8	.2	15.5	10.9
Hilo grass (*Paspalum conjugatum*)	28.64	.7	12.3	.3	13.6	18.4

TABLE II—Con.

ESTIMATED DIGESTIBLE NUTRIENTS OF HAWAIIAN FEEDING STUFFS

Feeding Stuff	Total dry matter in 100 pounds	Digestible nutrients in 100 pounds: Crude protein	Digestible nutrients in 100 pounds: Carbo-hydrate	Digestible nutrients in 100 pounds: Fat	Digestible nutrients in 100 pounds: Total	Nutritive Ratio
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	1:
FRESH GREEN ROUGHAGE—Con.						
Rhodes grass	35.21	1.3	17.6	.3	19.6	14.0
Side oats grama (partly dried)	60.53	3.1	22.9	.5	27.1	7.7
English and Italian rye grass (partly dried)	72.59	5.1	42.8	1.0	50.1	8.8
LEGUMINOUS FORAGE CROPS:						
Alfalfa	25.68	4.7	9.4	.2	14.5	2.0
Cowpea	15.74	2.2	7.6	.2	10.2	3.6
Wild cowpea (*Vigna sandwichensis*)	26.89	2.6	14.9	.1	17.7	5.8
Spanish clover *Desmodium uncinatum*	24.94	1.6	14.9	.1	16.7	9.4
Desmodium triflorum	34.78	3.8	17.1	.8	22.7	4.9
Pigeon pea (*Cajanus indicus*)	30.00	5.5	10.7	.9	18.2	2.3
Jack bean (*Canavali ensiformis*)	23.19	4.0	9.8	.3	14.5	2.6
WEEDS USED AS FORAGE:						
Pigweed (*Portulaca oleracea*)	4.80	.9	2.5	.0	3.4	2.8
Pualele (*Sonchus oleraceus*)	12.87	1.1	6.9	.3	8.6	6.8
Honohono (*Commelina nudiflora*)	10.57	.8	6.2	.1	7.2	8.0
Ki or Spanish needles (*Bidens pilosa*)	25.01	1.8	15.6	.1	17.6	8.7

TABLE II—Con.

ESTIMATED DIGESTIBLE NUTRIENTS OF HAWAIIAN FEEDING STUFFS

FEEDING STUFF	Total dry matter in 100 pounds	Digestible nutrients in 100 pounds: Crude protein	Digestible nutrients in 100 pounds: Carbohydrate	Digestible nutrients in 100 pounds: Fat	Digestible nutrients in 100 pounds: Total	Nutritive Ratio
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	1:
MISCELLANEOUS GREEN FORAGE:						
Prickly pear	5.4	.2	2.8	.1	3.2	15.0
Kolu (*Acacia farnesiana*)	40.00	5.3	20.5	.4	26.7	4.0
Banana tops	16.71	1.3	9.4	.1	10.9	7.4
Banana butts	5.78	.2	2.6	.1	3.0	14.0
Taro tops	15.46	1.2	9.7	.2	11.3	8.4
Sweet potato tops	12.33	1.9	6.4	.1	8.5	3.5
Ti (*Cordyline terminalis*) leaves	20.64	1.8	12.4	.2	14.7	7.1
Pakana (*Melilotus officinalis*)	38.72	4.5	17.7	.3	22.8	4.0
Rape	13.90	2.0	7.6	.3	10.2	4.1
Annual ilima (*Sida sp.*)	22.42	2.0	8.9	.2	11.3	4.6
Sisal waste	15.89	.5	8.1	.0	8.6	16.2
SILAGE:						
Para grass silage	19.52	.6	10.1	.1	10.9	17.1
Sorghum silage	23.30	.9	11.3	.4	13.1	13.5
Corn silage	18.40	1.1	7.3	.2	8.8	7.0
Corn cut for silage	23.55	1.0	13.9	.2	15.3	14.3
ROOT CROPS AS FORAGE:						
Cassava whole root	35.83	.5	30.5	1.4	34.1	67.2
Cassava peeling	31.25	.6	23.8	.5	25.5	41.5
Cassava peeled root	34.70	.4	31.2	.1	31.8	78.5

TABLE II—Con.

ESTIMATED DIGESTIBLE NUTRIENTS OF HAWAIIAN FEEDING STUFFS

Feeding Stuff	Total dry matter in 100 pounds	Digestible nutrients in 100 pounds				Nutritive Ratio
		Crude protein	Carbohydrate	Fat	Total	
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	1:
FRESH GREEN ROUGHAGE—Con.						
Cassava refuse (from crude extract of starch)	84.54	.7	73.5	.1	74.4	105.2
Cassava waste (first washing for starch manufacture)	83.70	.8	72.7	.2	73.9	91.3
Edible canna	26.25	.8	22.5	.1	23.5	28.3
Taro waste	29.27	.2	21.8	.2	22.4	111.0
Tacca pinnatifida	33.11	1.1	28.3	.1	29.6	25.9
Ti root (*Cordyline terminalis*)	32.66	1.5	27.8	.1	29.5	18.6
Beet, yellow tankard	5.88	.7	2.9	.0	3.6	4.1
Beet, long red	6.75	.8	2.6	.1	3.6	3.5
Taro whole root	39.45	.6	35.1	.1	35.9	58.8
Taro peeling	21.25	.4	17.3	.2	18.1	44.2
Taro peeled root	41.65	.7	37.2	.1	38.1	53.4
Sweet potato whole root	31.11	1.3	26.0	1.1	29.8	21.9
Sweet potato peeling	25.65	.8	19.7	1.0	22.7	27.3
Sweet potato peeled root	31.50	1.3	26.4	.2	28.1	20.6

TABLE II—Con.

ESTIMATED DIGESTIBLE NUTRIENTS OF HAWAIIAN FEEDING STUFFS

FEEDING STUFF	Total dry matter in 100 pounds	Digestible nutrients in 100 pounds				Nutritive Ratio
		Crude protein	Carbohydrate	Fat	Total	
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	1:
DRIED ROUGHAGE						
HAY FROM GRASSES:						
Redtop	91.20	2.0	50.1	.6	53.4	25.7
Rhodes grass	89.17	3.8	43.8	.7	49.1	11.9
Panicum plicatum	90.86	2.6	43.1	.9	47.7	17.3
Foxtail grass	90.03	5.2	43.4	.6	49.9	8.5
Sudan grass	90.52	3.4	44.6	.8	49.8	13.6
Tunis grass	90.52	2.5	46.0	.6	49.8	18.9
Rescue grass	90.63	5.5	43.0	1.0	50.8	8.2
Australian blue grass	90.52	3.3	48.6	.9	53.9	15.3
Natal redtop	90.54	2.2	46.8	.7	50.5	21.9
SMALL CEREAL HAY:						
Wheat straw	90.60	1.0	32.6	.6	34.9	33.9
Rice straw	89.11	1.1	31.6	.6	34.0	29.9
MEAL FROM HAY:						
Sudan grass meal	89.23	2.4	47.9	.2	50.7	20.1
Velvet bean vine meal (seed removed)	88.16	11.7	34.0	.3	46.3	3.0
Pigeon pea meal (seed removed)	89.85	11.2	37.5	.5	49.8	3.5
Sunn hemp meal	89.29	7.3	41.9	.2	49.6	5.7
Cowpea vine meal (seed removed)	88.32	10.2	36.2	.7	47.9	3.7

TABLE II—Con.

ESTIMATED DIGESTIBLE NUTRIENTS OF HAWAIIAN FEEDING STUFFS

FEEDING STUFF	Total dry matter in 100 pounds	Digestible nutrients in 100 pounds				Nutritive Ratio
		Crude protein	Carbohydrate	Fat	Total	
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	1:
DRIED ROUGHAGE—Con.						
Mixed feed consisting of 2 parts velvet bean vine meal, 1 part Sudan grass meal, 1 part cane-top meal	88.75	8.6	47.5	1.0	58.3	5.7
Mixed feed consisting of equal parts by weight of cowpea meal, algaroba meal, and molascuit (80 per cent molasses)	88.39	9.6	48.1	.7	59.2	5.1
ROOTS AND BY-PRODUCTS:						
Cassava peeling	88.01	1.7	66.9	1.3	71.5	41.0
Taro peeling	87.49	1.6	71.2	.8	74.6	45.6
Sweet potato peeling	87.19	2.6	69.7	3.3	79.7	29.6
Cassava whole root	87.57	1.0	77.1	.4	79.0	78.0
Taro whole root	87.87	1.5	78.3	.3	80.4	52.6
Sweet potato whole root	88.48	3.6	74.0	.7	79.1	21.0
Cassava peeled roots	87.53	1.0	78.7	.3	80.3	79.3
Taro peeled roots	87.91	1.4	78.5	.2	80.3	56.3
Sweet potato peeled roots	88.57	3.6	74.1	.5	78.8	20.8
Hog or broom corn millet roots	88.82	5.3	46.1	.3	52.0	8.8
MISCELLANEOUS:						
Sisal waste	95.00	3.0	47.8	.0	50.8	15.9

TABLE II—Con.

ESTIMATED DIGESTIBLE NUTRIENTS OF HAWAIIAN FEEDING STUFFS

Feeding Stuff	Total dry matter in 100 pounds	Digestible nutrients in 100 pounds				Nutritive Ratio
		Crude protein	Carbohydrate	Fat	Total	
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	1:
CONCENTRATES						
Brewers' grains	90.00	14.6	36.2	2.5	56.4	2.8
Molascuit	78.80	2.2	50.6	.1	53.0	23.0
Algaroba or kiawe bean	84.85	5.4	50.2	.4	56.4	9.4
Algaroba meal	92.81	6.0	54.8	.7	62.4	9.4
Algaroba meal, average pods, seed removed	82.51	2.8	52.4	.1	55.4	18.7
Algaroba meal, seed from average pods	85.76	24.7	41.1	3.3	73.2	1.9
Rice bran	90.01	6.0	35.2	8.9	61.2	9.2
Rice polish	89.50	8.2	47.0	10.5	78.8	8.6
Pigeon pea meal	90.33	15.6	57.4	1.2	70.4	3.5
Cowpea meal	90.20	17.1	57.5	1.3	77.5	3.5
Jack bean meal	92.82	17.7	57.5	1.9	79.4	3.4
Corn-and-cob meal	86.50	5.2	61.9	1.9	71.3	12.7
Velvet bean meal (seed and pod)	87.53	18.9	48.7	2.6	73.4	2.8
Soy bean waste (original)	22.40	4.5	14.4	.0	18.9	3.2
Soy bean waste (dried)	96.00	19.4	62.0	.0	81.4	3.2
Sake waste	36.53	9.6	15.2	.5	25.9	1.7
Molasses	76.67	1.4	51.7	.2	53.4	37.1
Coconut meal	88.82	18.9	39.2	7.5	74.9	2.9

In Table II, the digestible nutrients are estimated by combining the analyses of Table I with the table of the average digestibility of American feeding stuffs compiled by Henry and Morrison.[1]

No digestibility coefficients were available for some feeds, and in such cases, the coefficients of similar feeds were used. Because of the aproximate character of the whole table these cases were not given any special notation. The digestible protein in 100 pounds of a feeding stuff is found by multiplying the total crude protein in 100 pounds (as shown by the analyses in Table I) by the digestibility coefficient for crude protein in that feed. The digestible fiber and nitrogen-free extract are added together as digestible carbohydrate. The total of the digestible nutrients given in the sixth column of Table II was obtained by adding together the digestible protein, the digestible carbohydrates, and 2.25 times the digestible fat. The digestible fat is multiplied by 2.25 because of the fact that fat will produce 2.25 times as much heat as carbohydrates when used for suplying energy to the animal body.

THE NUTRITIVE RATIO

Because of the importance of protein to the animal body, the "nutritive ratio" is of value in calculating rations for live stock. This is the ratio of digestible crude protein to the other digestible nutrients in feeding stuffs, Since it is usually a fraction, it is expressed with a colon, as 1:8.9. It is found by dividing the sum of the digestible carbohydrates and 2.25 times the digestible fat by the digestible crude protein. The quotient is the second factor of the nutritive ratio. The nutritive ratio of a feed is said to be "narrow" when the proportion of crude protein to other nutrients is large, and to be "wide" when there is a small proportion of crude protein. For mixing feeds for dairy cattle a nutritive ratio of about 1:6 is usually recommended, while a wider ratio can be used for beef cattle. The nutritive ratios for the various Hawaiian feeding stuffs are given in the seventh column of Table II.

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[1] Loc. cit.

CALCULATION OF BALANCED RATIONS

Table II should be of use in estimating the relative values of the different Hawaiian feeding stuffs and determining the most promising local sources of supply. Table II can also be used in conjunction with tables of feeding standards for farm animals such as are given by Henry and Morrison[1] or by Fraps[2] for the calculation of rations for live stock. As the calculation of rations is rather a difficult process, the Hawaii Experiment Station will be glad to assist any who desire to make up a ration for a specific purpose if full data as to the feeds available and the animals to be fed (age, weight, for what purpose used, etc.) are sent to F. G. Krauss, Superintendent of the Extension Work, Haiku, Maui, or to the Hawaii Agricultural Experiment Station at Honolulu.

SUMMARY

(1) All the analyses of Hawaiian feeding stuffs made by the Chemistry Department of the Hawaii Experiment Station up to the present have been collected and arranged in a table convenient for comparison with standard tables of American feeding stuffs.

(2) On the assumption that the digestibility of Hawaiian feeding stuffs is about the same as for similar American feeding stuffs, a second table showing the approximate digestible nutrients of Hawaiian feeding stuffs has been prepared.

(3) These tables should be of use in estimating the relative values of different Hawaiian feeding stuffs, in determining the most promising local sources of supply to be developed, and in calculating rations for live stock.

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[1] Loc. cit.

[2] Fraps, G. S. Principles of Agricultural Chemistry. Easton Pa., 1913, pp. 493.